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Characterization and Corrosion Analysis of Al 7075 Hybrid Metal Matrix Composite Materials by Stir Casting Method

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Abstract—*Composite materials play a vital role at present modern industrial sector. Al7075 is an aluminium alloy which has good fatigue strength, average machinability and good thermal properties but has less resistance to corrosion. However Al7075 extensively finds it application in Aerospace and Aircraft Industries. Its high cost and foremost poor corrosion resistance limits its application. Our aim is to produce Al7075 with improved corrosion resistance. We study the corrosion behavior of base matrix Al combined with SiC and fly ash in two different compositions (10%SiC & 5%ash) and (15%SiC & 5%ash) using stir casting method. These two resultant are carried out for Impact test, tensile test and Hardness test. Together, both the samples are carried out for the study of corrosion in presence of Sea Water by Tafel polarization.*

Keywords*: Aluminium 7075, SiC, Fly Ash, Impact Strength, Tensile Strength, Hardness, Sea Water, corrosion study*

1. INTRODUCTION

Metal Matrix Composite is Composite material with two or more constituent parts, One being a metal and other material should some other metal or material, Such as a Ceramic or Organic compound. It has the properties of increased strength, High elastic modulus, High wear resistance, High service temperature, High thermal and electrical conductivity.

Composite material is combination of matrix & reinforcement. Its purpose is to transfer and to distribute the load to the reinforcement. This load transfer depends on the bonding, matrix and Reinforcement & fabrication technique. On the basis of corrosion resistance & other properties matrix can be selected. In general matrix material (Mg, Cu, Pb, Ag, Fe, Sn, Zn, Al, Ni and Si) are used, but Al, Mg, Ti are widely used as matrix material.

Recently researchers from all over the world are mainly focusing on Al, because of improved corrosion resistance, good mechanical properties. In the last few decades MMC based on Al are famous research area in field of material processing. Most of the research process has been dealing with Al matrix with SiC reinforcement with light weight in combination of high stiffness and high strength. This is because Aluminium are low weight and used widely in most of the industries. In addition better corrosion resistance and formability of Al matrix can be improved by using aluminium 7075 with varying proportion of SiC and Fly Ash.

1.1 Applications of Al7075

Aluminium 7075 is mostly used in applications of transport, marine, aviation and automotive industries. Due to its high strength and less weight it used in rock climbing equipment, components of bicycle, inline skating-frames & glider airframes. For Chassis Plates of Hobby grade RC models, Manufacture of M16 rifles for American military also Al7075 is commonly used. Because of its high strength, less density, thermal properties, Al7075 is mostly used in tool manufacturing.

2. MATERIALS AND PROCESSING METHOD

The materials used in the present research consist of Aluminium alloy (7075) as matrix. Its chemical composition (%) is Zn=5.10-6.10, Mg=2.10-2.90, Cu=1.20-2.00, Cr=0.18-0.28, Fe=0.50(Max.), Si=0.40(Max.), Mn=0.30(Max.), Ti=0.20(Max.), others 0.05(Max.) each -0.15(Max.) total, Balance=Al. It has a rigid property of high strength, hardness, high density, high thermal properties and wear resistance. The aluminium matrix was combined with reinforcement materials SiC and Fly Ash in two different compositions.(i) Al7075, (ii) Al7075 + 10%SiC + 5%Fly Ash and (iii) Al7075 + 15%SiC + 5% Fly Ash, by Stir Casting Method

Fig. 1: Fly Ash from plantain leaves

Fig. 2: Al7075 bar

Step1: Aluminium alloy is heated above 800^0C in furnace for three hours.

Step 2: SiC and Fly Ash is heated at 1000^0C in another furnace for some time.

Step3: Melted Aluminium, SiC & Fly Ash are mixed in the crucible made up of graphite.

Step4: Then the crucible made up of graphite is kept inside the furnace.

Step 5: Then molten metal was stirred for 10 min at speed of 250 rpm.

Step6: Simultaneously, before pouring dies are preheated at 300^0C in furnace for 1 hour.

Fig. 3: Molten metal in crucible

Fig. 4: Molten metal is poured in die

Step 7: At last the molten metal was poured into the preheated die & then the metal is allowed to solidify for few hours.

Sample 1: AL7075

Sample 2: Al7075+10%SiC+5%Ash

Sample 3: Al7075+15%SiC+5%Ash

3. TESTING AND RESULTS

For the good design and usage of these composite plates, it is essential that its ultimate strength and mechanical properties need to be determined. Hence various tests are conducted for all 3 samples.

Sample 1: Al7075, Sample 2: Al7075 + 10%SiC + 5% Fly Ash, Sample 3: Al7075 + 15%SiC + 5%Fly Ash

3.1.1. TENSILE TEST

Tensile strength for the both samples are carried out in tensile testing machine. The result from this test is commonly used for selection of a material for an application. Ultimate tensile strength, elongation and reduction in areas are measured in this testing machine. Standard Test Methods for Tension testing of Metallic Materials ASTM E8 is used.

Fig. 5: Tensile test

Sample id	Ultimate strength (MPa)	%elongation
Sample1	147	18
Sample2	198	12.5
Sample3	202	9.75

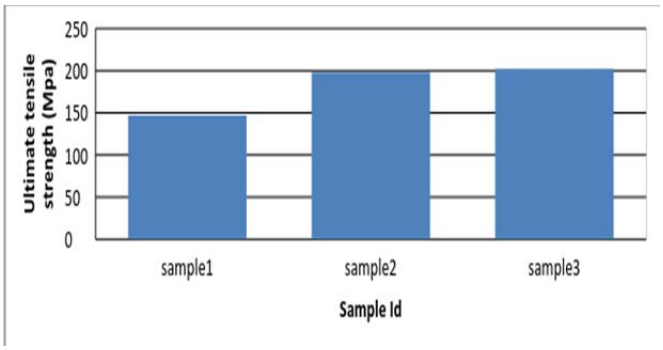

Fig. 6: Ultimate tensile strength of casted samples

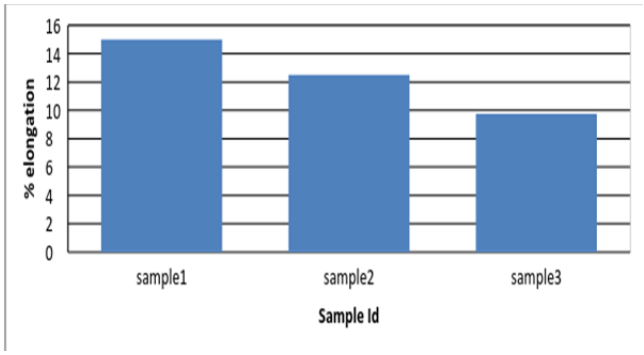

Fig. 7:.% Elongation of casted samples

3.1.2. HARDNESS TEST

The hardness of both samples are measured using Rockwell hardness measuring machine by applying a major load of 15kg& Minor load of 3kgand Dwell Time of 2seconds. ASTM E-18 is commonly used hardness test method. It used to measure the depth of indentation formed by a load or force on indenter.

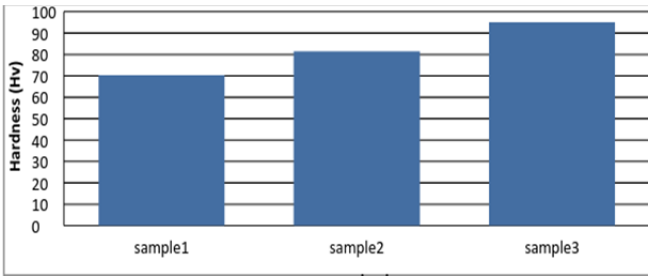

Fig. 8: Hardness graph for the casted samples

3.1.3. IMPACT TEST

The purpose of impact testing is to measure an object's ability to resist high-rate loading. It is usually thought of in terms of two objects striking each other at high relative speeds. Impact resistance can be one of the most difficult properties of quantity. The impact strength of both samples was measured using IZOD testing machine.

Fig. 9: Impact testing machine

Fig. 10: Samples of impact test

SAMPLE Id	Impact strength
Sample1	0.2
Sample2	0.7
Sample3	1.2

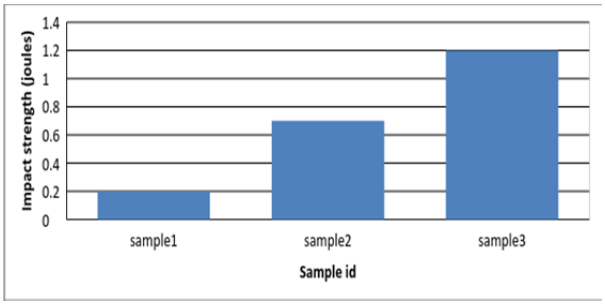

Fig. 11: Impact strength of casted sample

3.2. SEM ANALYSIS

A Scanning Electron Microscope provides details surface information by tracing a sample in a raster pattern with an electron beam

SAMPLE 2

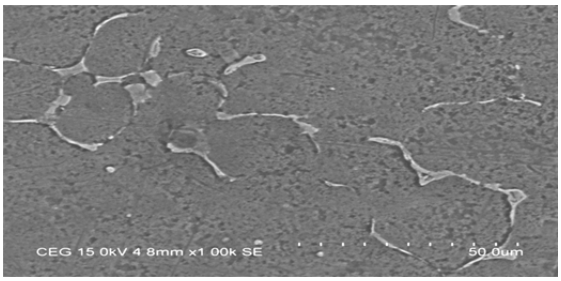

Fig. 12. SEM image of sample 2

SAMPLE 3

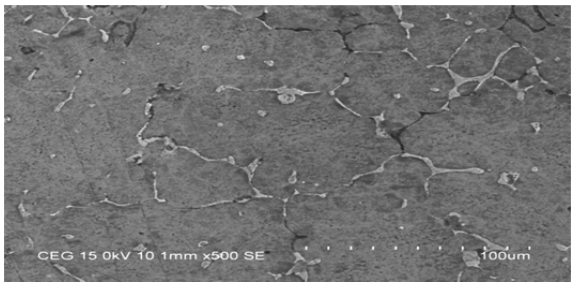

Fig. 13. SEM image of sample 3

The above Fig. 12 & Fig. 13 shows the distribution of the reinforcement particles silicon carbide and fly ash. The distribution is seen uniformly in the casted sample this is due to proper stirring of the base metal and the reinforcement, maintaining uniform speed during the stir casting process. We can also see a grain boundary in the image this is due to segregation of magnesium particles which indicates the hardness is high at the grain boundaries.

3.3. CORROSION ANALYSIS TEST

Corrosion is an electrochemical process of oxidation and reduction reactions. As corrosion occurs, electrons are released by the metal (oxidation) and gained by elements (reduction) in the corroding solution. Because there is a flow of electrons (current) in the corrosion reaction, it can be measured and controlled electronically.

A weighed sample coupon of metal introduced into the corrosion process and after desired exposure period removed, cleaned of all corrosion products and reweighed. Weight loss can be converted to average corrosion rate using Faraday's law. There are ASTM standards G1, G4 and G31 for preparing, cleaning and evaluating corrosion test specimens, conducting corrosion coupon tests in plant equipment and

laboratory immersion corrosion testing. Using corrosion coupons for weight loss (corrosion rate) measurements has advantages such as cheap and simple, permits analysis of corrosion products and can easily be done in a laboratory or on service equipment.

GRAPH (SAMPLE 2)

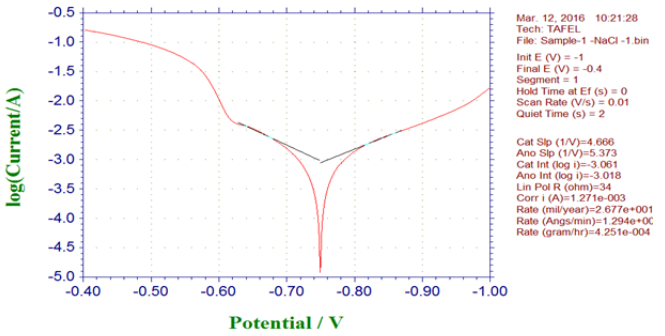

Fig. 14.Tafel plot image of sample 2

Typical cathodic polarization curves with respect to Tafel behavior are also given. Extrapolation of cathodic and anodic Tafel slopes back to the corrosion potential (V) are shown in Fig. 15. Intersection point corresponds to corrosion current density or corrosion rate. At the corrosion potential, rate of cathodic reduction is equal to rate of anodic reaction (metal corrosion).

GRAPH (SAMPLE 3)

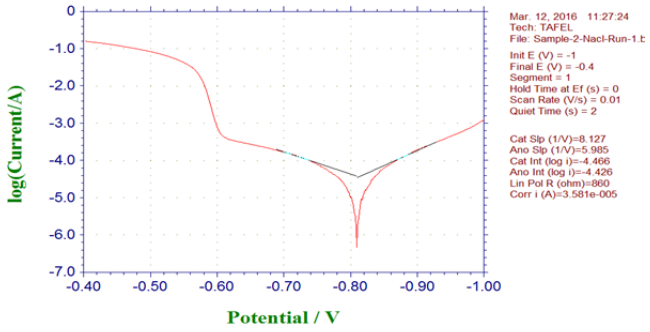

Fig. 15.Tafel plot image of sample 3

Typical cathodic polarization curves with respect to Tafel behavior are also given. Extrapolation of cathodic and anodic Tafel slopes back to the corrosion potential (V) are shown in Fig. 16. Intersection point corresponds to corrosion current density or corrosion rate. At the corrosion potential, rate of cathodic reduction is equal to rate of anodic reaction (metal corrosion).

4. 4. CONCLUSION

In this research work, a new composites (Al-SiC-Fly Ash) is formulated by stir casting process. In this stir casting method Al7075 is casted with different compositions of Sic (10%, 15%) and Fly Ash of (5%) respectively. Thus desirable properties, SEM Images & Corrosion test for both the samples are tested using ASTM standard, Scanning Electron Microscope and Electrochemical Corrosion Analysis Method respectively.

- Thus the result proved that stir casted alloy Al7075 with reinforcement materials (15%SiC & 5% Fly Ash) is superior to base alloy Al7075 when compared with desirable properties.
- Also toughness of the composite was determined by using Izod test. As we increase the amount of reinforcement materials the toughness value gradually increased.
- Hardness and tensile strength of composites also showed the same results as like toughness. As we increase the amount of reinforcement materials the both hardness and tensile strength values also gradually increased. Hardness and Tensile strength of the composite was determined by Rockwell hardness machine and Tensile testing machine respectively.
- Thus the corrosion resistance of composite material was improved by addition of Al7075 with reinforcement materials (15%SiC & 5%Fly Ash).
- Hence these light weight composites can be used, where weight of an object is primarily considered as like in the aerospace industries and ship industries.

From the above results we find that **sample 3 (Al 7075+15%SiC+5%Fly Ash)** having good toughness, hardness, tensile strength and also having the high corrosion resistance. So that these composites could be used in those sectors where light weight and good mechanical properties are required as like in automobile, marine and space industries.

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